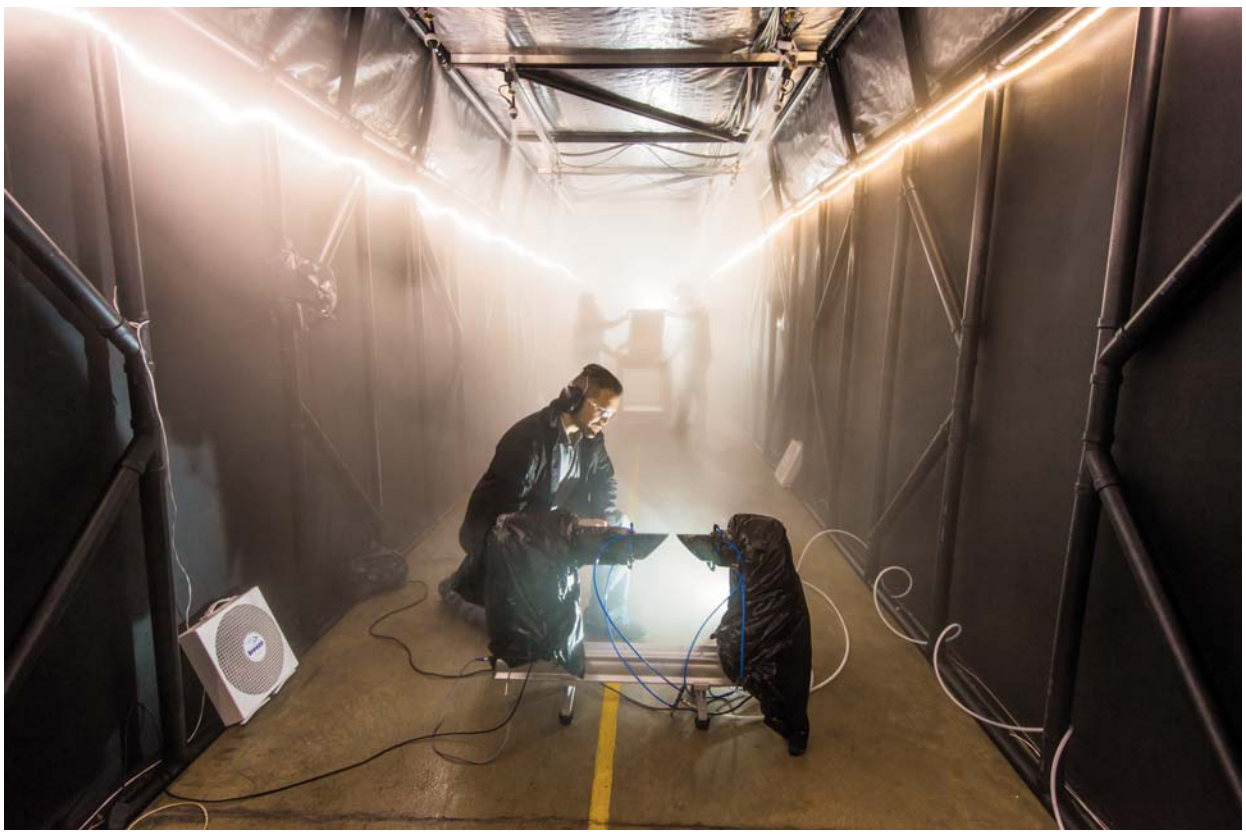
Fog on demand



Sandia-operated facility makes testing optics more cost-effective, efficient

By Heather Clark

Fog can play a key role in cloaking military invasions and retreats and the actions of intruders. That's why physical security experts seek to overcome fog, but field tests of security cameras, sensors, or other equipment are hampered by fog that is either too thick or too ephemeral.

Until now, collecting field test data in foggy environments was time-consuming and costly. "Fog is difficult to work with because it rarely shows up when needed, it never seems to stay around long enough once you're ready to test, and its density can vary during testing," says systems engineer Rich Contreras (formerly 6525, now 2134).

That's why he and others started thinking about developing a controlled fog environment for sensor

(Continued on page 4)

ANDRES SANCHEZ (6633) checks an instrument that measures the particle size and concentration in the atmosphere inside one of the world's largest fog chambers developed by Sandia. (Photo by Randy Montoya)

Sandia is NM's healthiest large employer

Albuquerque Business First has named Sandia the state's healthiest large employer for 2015. Out of a possible 100 points, Sandia earned 86.92 in the nationally benchmarked competition. The national average is 49.23. See **page 2.**

Sandia LabNews

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Sandia National Laboratories

'My lab can do this!'

Paul Hommert reflects on 5 years as Sandia president and Labs director . . . Story, photos on pages 6-7.

Pavel Bochev receives DOE's E.O. Lawrence Award

By Neal Singer • Photo by Randy Montoya

Pavel Bochev (1442), a computational mathematician, has received an Ernest Orlando Lawrence Award for his pioneering theoretical and practical advances in numerical methods for partial differential equations.

"This is the most prestigious mid-career honor that the Department of Energy awards," says Bruce Hendrickson (director 1400, Computing Research).

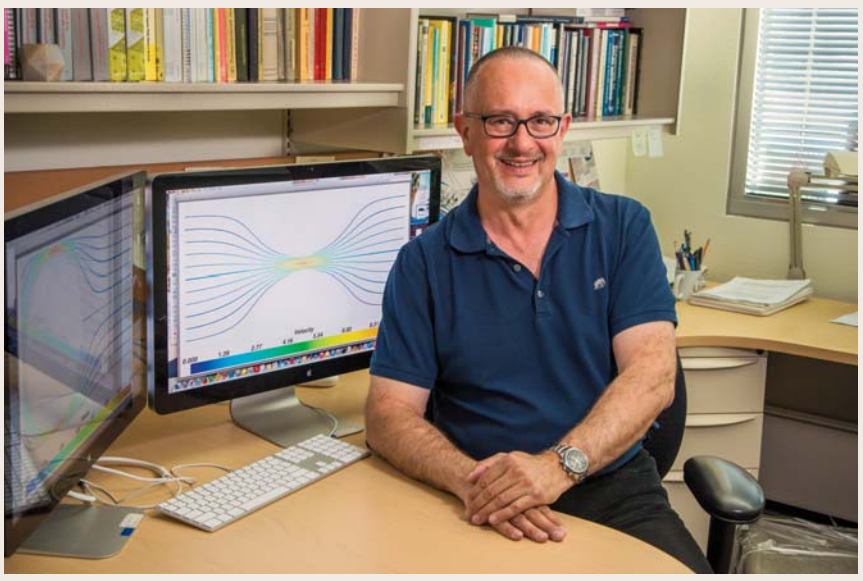
Lawrence Award recipients in nine categories of science each will receive a medal and a $20,000 honorarium at a ceremony in Washington, D.C., later this year.

In the category "Computer, Information, and Knowledge Sciences," Pavel's work was cited for "invention, analysis, and applications of new algorithms, as well as the mathematical models to which they apply."

Says Pavel, "I am deeply honored to receive this award, which is a testament to the exceptional research opportunities provided by Sandia and DOE. Since joining Sandia I've been very fortunate to interact with an outstanding group of researchers who stimulated and supported my work. These interactions, as well as funding from the Advanced Scientific Computing Research Program of DOE's Office of Science and the ASC program of the National Nuclear Security Administration, helped shape, grow, and mature the research effort leading to this recognition."

Said Energy Secretary Ernest Moniz, "I congratulate the winners, thank them for their work on behalf of the department and the nation, and look forward to their continued excellent achievement."

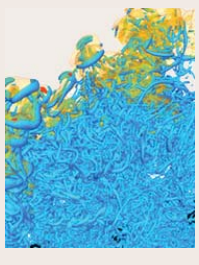
The Lawrence Award was established to honor the memory of Ernest Orlando Lawrence, who invented the cyclotron — an accelerator of subatomic particles



PAVEL BOCHEV, winner of DOE's E.O. Lawrence Award. (Photo by Randy Montoya)

— and received a 1939 Nobel Prize in physics for that achievement. Lawrence later played a leading role in establishing the US system of national laboratories.

The most recent prior Sandia recipient of the Lawrence Award is Fellow Jeff Brinker, who received the honor in 2002.



RAPTOR code

RAPTOR is a turbulent combustion code targeted at transportation power and propulsion systems. Insights from RAPTOR could lead to more efficient internal combustion engines and gas turbines. Read the latest on **page 3.**

Inside . . .

NW legacy hardware

The Nuclear Weapon Legacy Hardware collection is a teaching resource to connect succeeding generations of nuclear weapons engineers to the engineering work of past generations. Read about it on **page 5.**

That's that

With graduation season upon us, I wonder: How old were you when you earned your degree? Most people who go through the "normal" four-year undergraduate program get their diploma at age 21 or 22.

That model, though probably still the norm, is not as fixed in stone as it once was. In some cases, life circumstances, choices, and priorities may mean deferring college for years or even decades. Case in point: Sandia retiree Elaine Lieberman earned her degree from UNM just this year at age 74 — "74 years young," as her husband, Mort, also a Sandia retiree, puts it.

Elaine's 4.0 GPA at UNM is testimony to her intelligence, of course, but also speaks to the fact that older students can and do excel in what is generally considered a young person's arena.

My own experience falls somewhere between the two. After an unsuccessful early attempt at college (my priorities were elsewhere), I dropped out for several years and worked a variety of jobs, mostly in construction, before deciding, while standing in the bottom of a deep ditch on a building site, that I had to go back to school.

I graduated from the University of Montana at age 29. I was happy to get out of that ditch, but, astonishing as it may sound, there are days when I think back on those times with something like nostalgia. At the end of a shovel, you bond with your workmates in a way that I have rarely experienced since. We laughed a lot, sweated together, and, yes, we ached together, too, every single day. We were a band of brothers.

At the time, when clawing my way out of that ditch seemed like the most important thing in the world, I was convinced I'd just wasted several years. Funny thing is, though, looking back I don't consider that time to have been wasted at all. If I'd gone the "normal" route, I'd have never met my wife, my kids wouldn't exist in this world, and I'd never have ended up at Sandia. And, too, just as you can see a lot from the top looking down, you also see things in a different way from the bottom of a deep hole. I'm glad to have had that perspective.

* * *

On this subject, I came across a news item the other day about a boy in California who just graduated from college at age 11 with three associate degrees. The boy, Tanishq Abraham, is a member of Mensa and is obviously brilliant. (A little sidebar here: Tanishq's sister Tiara also belongs to Mensa; she joined at age 4.) Tanishq says he wants to be a doctor and medical researcher. And, oh, yeah, president of the United States. Don't bet against him.

While Tanishq's academic achievements are impressive — notable enough to have been reported in the national media — they aren't unprecedented. Reading about him piqued my curiosity so I did a little on-line research. Looks like the youngest-ever college grad was Michael Kearney, now 31, who earned a bachelor's degree in anthropology at age 10 from the University of South Alabama and went on to even greater achievements as he grew up.

Here's a little bit about Michael from Wikipedia: "He spoke his first words at 4 months. At the age of 6 months, he said to his pediatrician 'I have a left ear infection' and learned to read at the age of 10 months. When Michael was 4, he was given multiple-choice diagnostic tests for the Johns Hopkins precocious math program. Without having studied specifically for the exam, Michael achieved a perfect score."

Reading about Michael and Tanishq — and there are other boys and girls of similar accomplishment — I almost wonder if they represent some sort of post homo-sapiens variant of our kind. Their off-the-charts intelligence seems to be the stuff of science fiction. In any case, I do know this: We need to recruit prodigies like this to Sandia.

On second thought, maybe we already do.

See you next time.

— Bill Murphy (MS 1468, 505-845-0845, wtmurph@sandia.gov)

Sandia healthiest NM employer

By Valerie Larkin

Sandia has been named New Mexico's Healthiest Large Employer for 2015.

Albuquerque Business First presents the award each year to employers that demonstrate a commitment to fostering health and wellness in the workplace. Winners are chosen in three categories: small companies (2–150 employees), medium companies (151–499 employees), and large companies (more than 500 employees).

To compete for the title, employers complete a detailed survey and submit a description of their wellness program and philosophy. Nominees are scored using the Healthiest Employer Index, created by a national benchmarking firm to measure organizations' wellness culture and leadership commitment, foundational components, strategic planning, communication, programming and interventions, and reporting and analysis.

Out of 100 possible points, Sandia earned 86.92. The national average is 49.23.

In the award citation, Sandia was recognized for launching the HBE Health Action Plans, embodying a wellness culture, demonstrating high program participation rates, reducing health risks among employees, and keeping health care costs lower than the national average.

HERE'S TO YOUR HEALTH – Mary Romero Hart (3510), Jessika Brown (3334), and Debra Menke (3334), left to right, celebrate at the recent Albuquerque Business First ceremony where Sandia was named the healthiest large employer in New Mexico. (Photo by Guadalupe Chavez)

Sandia also won the award in 2011 after implementing the Virgin Pulse HealthMiles incentive program as part of a comprehensive strategy to increase employees' physical activity.

Renee Holland, manager of Healthcare and Support Services (3334), says, "We are very honored to receive the top honor among so many other great New Mexico companies. At Sandia, we strive to promote a healthy workforce and working environment. This award celebrates the success we have achieved in building a culture of health over the past 20 years and recognizes the strong executive leadership support for HBE's broad range of on-site services."

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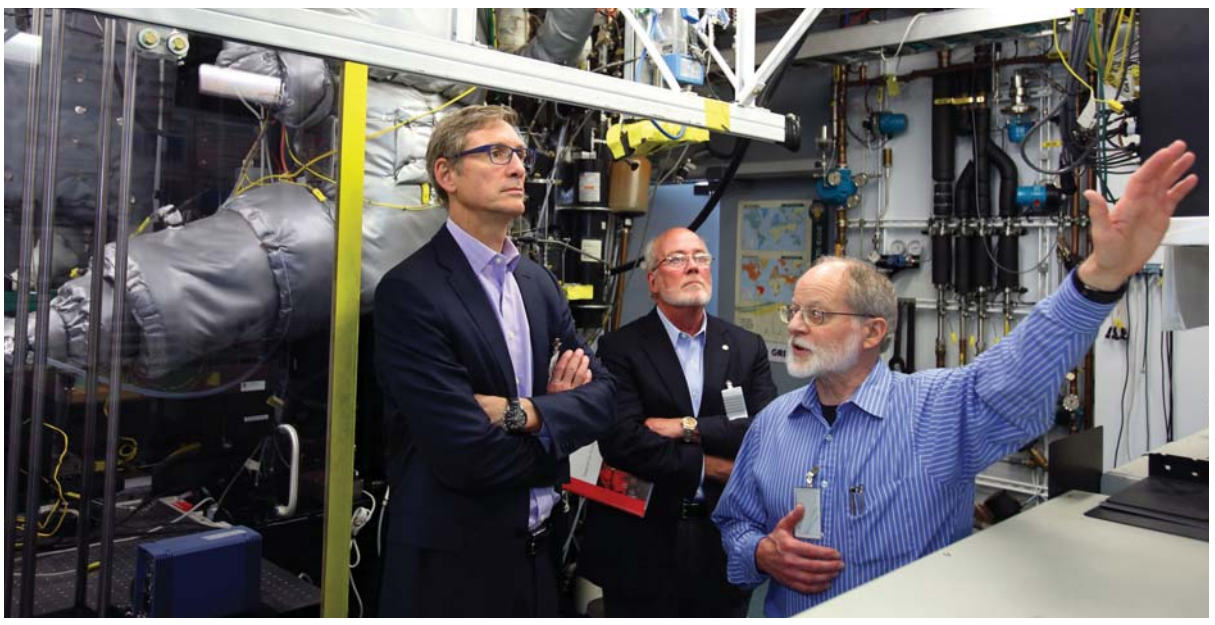
LOCKHEED MARTIN

Cummins CEO visits Combustion Research Facility



CUMMINS CHAIRMAN and Chief Executive Officer Tom Linebarger, left, and Vice President and Chief Technical Officer John Wall, center, visited the Combustion Research Facility on Thursday, May 28. Kamlesh Patel (8625) briefed the visitors on Sandia's microfluidic technology and Terry Johnson (CRF) provided an update on the free piston alternator project. Linebarger and Wall also visited Jeff Koplow's (8366) Sandia Cooler and Twistact Laboratory and John Dec's Low-Temperature Gasoline Combustion Engine Laboratory. In the photo here, John (8300) explains current research to the two visitors. "Sandia's Combustion Research team has had a strong working relationship with Cummins over the years," says CRF senior manager Art Pontau. "This executive visit gave the Cummins visitors the opportunity to see some of our latest forward-looking work and explore broadening our partnership in new technical areas." (Photo by Dino Vournas)

RAPTOR turbulent combustion code selected for next-gen supercomputer readiness project

By Patti Koning

RAPTOR, a turbulent combustion code developed by Sandia National Laboratories mechanical engineer Joseph Oefelein (8351), was selected as one of 13 partnership projects for the Center for Accelerated Application Readiness (CAAR).

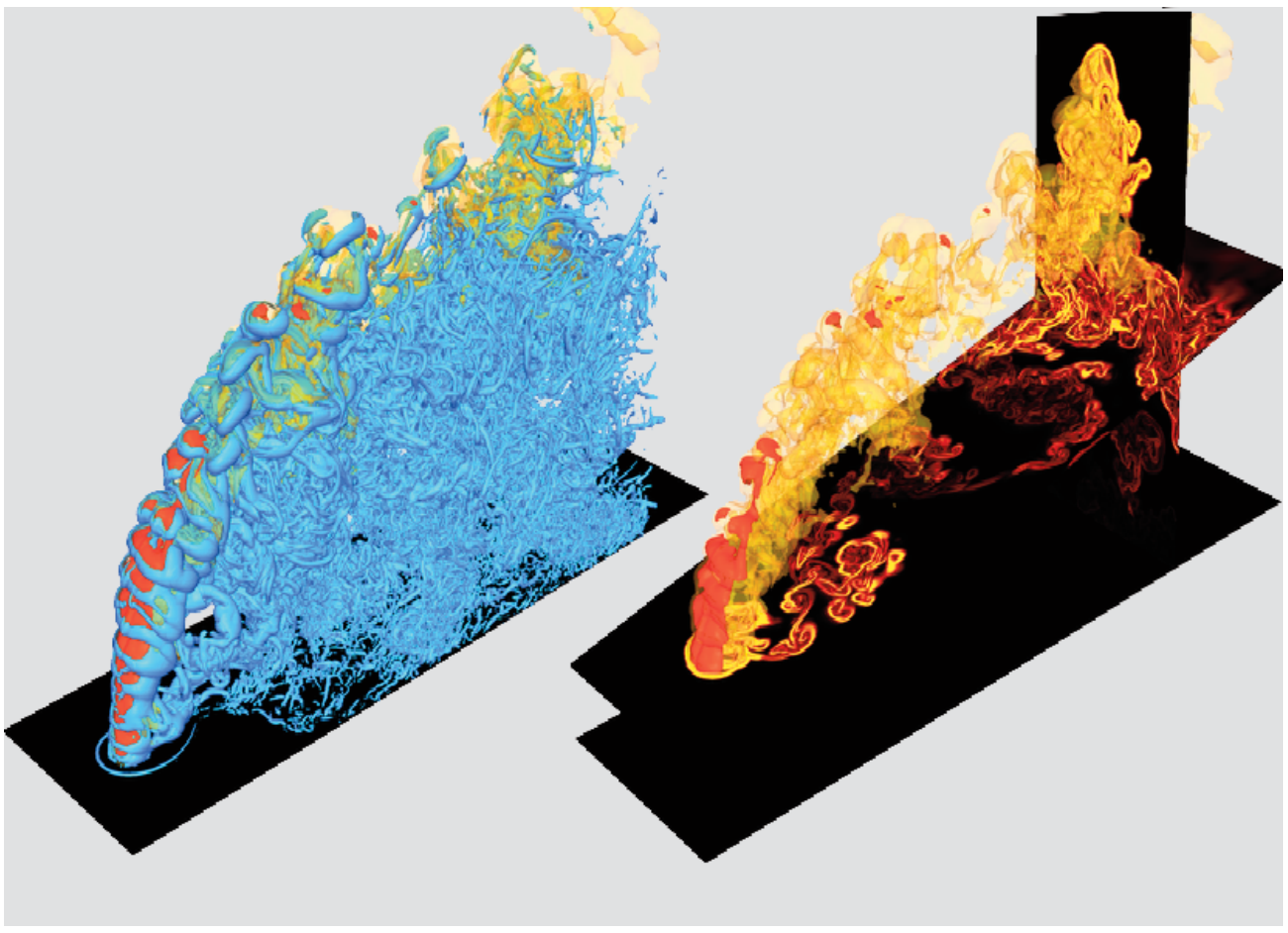
CAAR is a DOE program located at the Oak Ridge Leadership Computing Facility. It is focused on optimizing computer codes for the next generation of supercomputers.

Developed at Sandia's Combustion Research Facility, RAPTOR is a turbulent combustion code targeted at transportation power and propulsion systems. Scientific insights gained from RAPTOR could enable increased efficiency and reduced emissions in internal combustion engines and gas turbines.

"RAPTOR was chosen as a partnership project for its importance in discerning the complex fuel injection and combustion processes in modern engines and because it has demonstrated good scaling properties for operation on massively parallel supercomputers," says Joseph.

Future supercomputers will use increasingly complex arrangements of multicore processors and graphics processor units to minimize electrical power consumption. With each new generation of supercomputers, scientists must adapt their complex codes to leverage advances in computational power and speed.

The CAAR partnership project will support preparations to operate RAPTOR on the Summit supercomputer, set to be delivered to Oak Ridge National Laboratory in 2017 and available to researchers in 2018. Summit is expected to provide at least five times the performance of the Oak Ridge computing facility's current supercomputer, Titan.



THESE IMAGES ARE REPRESENTATIVE visualizations of a liquid n-decane jet being injected into a cross flow of air at high-pressure supercritical conditions. The image on the left shows the structure of the vorticity field downstream of the jet. The image on the right shows two iso-contours of mixture fraction (Z) showing the location of the compressed liquid core (red) and Z=0.5 (yellow). Also shown are 2-D cuts of the corresponding scalar dissipation rate. Collectively, these images show the unsteady nature of coupled velocity and scalar-mixing and its overall impact on local combustion processes.

Bay area high school girls honored for math, science achievements

Mentorship opportunities key to Sandia recognition program

By Patti Koning

Sandia has presented its annual Math and Science Awards to 31 girls from area high schools, celebrating their academic accomplishments and potential.

"I want to congratulate each of you for your academic excellence and encourage you to continue your passion for math and science," Div. 8000 VP Marianne Walck said to the students during the May 20 ceremony. "It's frustrating that women are still underrepresented in many technical fields. At this event you will meet Sandia women working in math and science whom I hope will serve as inspiration and encouragement for what is possible for your future."

Now in its 24th year, the Math and Science Awards program is designed to encourage high-achieving young women to continue studying STEM (science, technology, engineering, and math) subjects and create mentoring opportunities. Teachers from 17 high schools in Livermore, Dublin, Pleasanton, Tracy, Lathrop, Manteca, Stockton, and Oakland nominated students they deemed outstanding in math and science.

The winners also were recognized by state and federal officials. Assemblywoman Catharine Baker of San Ramon presented certificates to winners, as did representatives from the offices of Reps. Barbara Lee, Jeff Denham, and Eric Swalwell.

Mentoring relationships initiated

Those honored and their families learned about different careers in math and science by mingling with Sandia researchers. As part of the ceremony, mechanical engineer Myra Blaylock (8253) and technical editor/writer Emmeline Chen (8941) shared their personal stories. Both women's career paths have gone in unexpected directions.

"I didn't take a straight path to get to where I am now, but that led to some great experiences," said Myra. "Always keep learning, and don't be afraid to switch career paths."

Emmeline advised the girls to remain open to opportunities. "Very soon, you will have many important decisions to make about where to attend college, what major to choose, and which opportunities to pursue,"

SANDIA VP MARIANNE WALCK, center, celebrates with Dublin High School student Alessia Stewart, one of 31 high school girls honored by Sandia for academic achievement in math and science. (Photo by Dino Vournas)

she said. "It may feel overwhelming, but consider these choices a gift, and remember that no single decision is going to determine your life path."

Each winner was paired with a Sandia mentor, a woman working in a STEM field.

Sandia CaliforniaNews

"Our goal is that these introductions are the start of a long relationship," said Cathy Branda (8633), a manager in Sandia's biological sciences program and chair of the Math and Science Awards. "When I was a student, connecting with women already working in my field was a great help. We hope to provide that opportunity to these talented young women."

The winners of the 2015 Sandia Math and Science Awards:

Outstanding Achievement in Mathematics

- Alexandra Hawkins, Amador Valley HS
- Illeanna Gutierrez, Castlemont HS
- Meylin Serrano, Coliseum College Prep. Academy
- Katherine Raja, Dublin HS
- Suhasiny Naik, Foothill HS
- Megan McCandless, Granada HS
- Aiyana Bergren, Lathrop HS
- Emma Kristovich, Livermore HS
- Kelsey Conway, Livermore Valley Charter Prep. HS
- MaKayla Dodd, Manteca HS
- Khadija Flowers, McClymonds HS
- Jasmeen Sandhu, Merrill F. West HS
- Amy Wise, Millennium HS
- Kayla Wilson, Sierra HS
- Pallavi Adapa, Tracy HS

Outstanding Achievement in Science

- Catherine Tu, Amador Valley HS
- Susana Lopez, Castlemont HS
- Jessica Rodriguez, Coliseum College Prep. Academy
- Alessia Stewart, Dublin HS
- Vanessa Angeles, Granada HS
- Medha Kothari, John C. Kimball HS
- Lisa Thongmanivong, Lathrop HS
- Christine Cummings, Livermore HS
- Camille Zaug, Livermore Valley Charter Prep. HS
- Kyleigh Range, Manteca HS
- Yuliza Rios-Oregon, McClymonds HS
- Jessica Huynh, Merrill F. West HS
- Leanne Velasco, Millennium HS
- Candice Lao, Sierra HS
- Isabel Ortiz-Gelder, Tracy HS
- April Vang, Weston Ranch HS

THE CONTROLLED ATMOSPHERE in Sandia's fog chamber could make testing optics of sensors more cost-effective and efficient. The team that maintains and operates the fog chamber includes, left to right, Gabriel Lucero, Andres Sanchez, and Crystal Glen (all 6633), Matthew Tezak (6632), and Mark S. Johnson (1118). (Photo by Randy Montoya)

Fog chamber

(Continued from page 1)

testing. Sandia has developed a fog chamber — one of the world's largest — that meets the needs of the military, government agencies, and industry. The chamber is in a tunnel owned by the Air Force Research Laboratory.

"The ultimate goal of this whole endeavor is to defeat fog," Rich says. "From physical security and force protection aspects, as scientists and engineers who care about national security, we want to be able to make it so that a security force person at a site has the ability to maintain uninterrupted situational awareness."

Researchers say the chamber will help develop and validate cameras' and sensors' abilities to penetrate fog, knowledge that could lead to improved surveillance at sites. The chamber also could be used to answer some fundamental optics questions, which in time could lead to improved security camera lenses and medical imaging equipment, safer aircraft landings, and better vision for drivers in fog.

"People need to see through fog," says optical scientist Gabe Birch (6524). "So much of the US population is on the coastlines in places where fog exists. If you could discover an inexpensive technique to see better through it, there are a lot of people in industry who would be interested in that."

Cloud microphysics used to characterize fog, prolong testing

This is not your Halloween party fog machine. Sandia's fog chamber is 180 feet long, 10 feet tall, and 11 feet wide. The chamber is enclosed by air curtains and rubber baffles to entrap fog closely like real-world fog. Tunnel walls are covered with a special black paint to reduce reflections and improve data quality, Rich says.

Walk a few steps down the hallway when the chamber's fog is at full strength and a sense of disorientation washes over an observer as the walls, ceiling, and entranceway disappear and people only a few feet away fade first into dark, obscure silhouettes and then become invisible.

Sandia researchers use cloud microphysics to generate the fog for video analytics, environmental testing, and new sensor development. Currently, the chamber's fog resembles that found in coastal regions, but output can be customized to produce fog similar to that found in any location, says Crystal Glen (6633), an aerosol scientist. Researchers eventually hope to add smoke and dust to the chamber's repertoire.

In the atmosphere, fog forms from a seed particle, such as pollen or sea salt, surrounded by layers of water. Seed particles differ based on the fog's location. Sandia currently uses sodium chloride, or sea salt, as its seed particle to mimic the composition and particle size of coastal fog. By consulting journals or traveling to a region, researchers can measure the droplet size distribution and chemical composition of different fogs worldwide and then alter the seed particles to customize the fog.

The longer the fog's seed particles hold onto the water layer, the longer they are visible for testing. The length of the test is dependent on the relative humidity in the chamber.

Crystal mixes a solution of sodium chloride and water that produces the desired core particle seed diameter. The pre-mixed solution is then sprayed into the chamber where the relative humidity is above 95 percent. The initial sprayed droplets are roughly 2.3 times their dry diameter.

The deliquescence point, or the amount of relative humidity required for a particle to take on water, happens at 72 percent relative humidity for coastal fog, primarily composed of sodium chloride. The amount of water clinging to the seed particle grows exponentially from there. This process happens naturally in the atmosphere and leads to fog and cloud formation, Crystal says.

To speed up Mother Nature, Crystal checks the rate at which a particle will gain or lose water in relation to the chamber's relative humidity, termed the hysteresis curve for water interactions with sodium chloride. This information allows the team to target a specific relative humidity and obtain a desirable size for the wet particles, so the droplet size distribution is close to what is found in natural fog, she says. While the fog generated in the chamber is not identical to fog formed in nature, it is physically representative and extremely useful for research involving optical transmission and visibility, she adds.

Typically, gravity causes the fog to settle before the decrease in relative humidity takes effect. The fog density can remain constant for up to 30 minutes, allowing a test to last 10-20 minutes. Adding a 30-second blast of fog particles can prolong the testing, Crystal says, adding that the fog's density can be controlled by the amount sprayed into the chamber or the particle size.

Optics experts see potential of controlled fog

The layer of water around the fog seed particles either absorbs the photons, the elementary particles and waves that make up light, or causes them to change direction in random ways, so that by the time they reach the cameras being tested, the wavelengths being picked up create a fuzzy image, Gabe says.

Optics researchers refer to fog — and seeing through bodily tissue in medical imaging — as "scattering environments." Sandia optical engineer David Scrymgeour (1728) likens the photons' movements in these environments to walking through a sunny, full parking lot and seeing the glints of light bounce in every direction off windshields.

In fog, it's the scattering of the photons that causes car headlights or a pedestrian's flashlight beam to illuminate an entire scene, making vision even more difficult, David explains.

In physical security, "the cameras are very sensitive to the sizes of fog particles and how the photons scatter. That's why it's so important to know the sizes of particles that we have in the environment, which is something that we in the optical field have not really had before," Gabe says. "It enables a lot of very interesting testing because you can finally characterize your system's performance by knowing the scattering that's happening in the environment."

Fog chamber tests could lead to security camera improvements

For the military or any agency trying to physically secure a site, not knowing the exact ranges that cameras can penetrate fog in a particular environment makes it difficult to choose the correct cameras and sensors and their placements, Rich says.

Gabe explains: "It's very difficult to quantitatively compare all those modalities together with the same fog and in the same conditions because you go outside and five minutes later it could be very different."

Once the chamber's fog density is set, cameras or sensors mounted at one end of the tunnel are monitored to see how well they detect humans or custom targets, Rich says.

Different types of lighting representing specific sites could be installed in the chamber to see the combined effect of fog and lighting or the desired time of day, he says.

Examples of tests include showing raw data from various cameras, characterizing how different wavelengths and polarization states are influenced by fog, comparing different optical systems in a controlled foggy environment, and resolution testing to see how the optical properties and resolution degrade in a variety of foggy environments, Gabe says.

Fog chamber could provide answers for optics research

The fog chamber also could be used to answer fundamental scientific questions.

"When you look at the huge gap from the visible spectrum all the way up to the far infrared, no one can say we absolutely understand how the polarization states at all these different wavelengths behave as they go through a foggy atmosphere," Gabe says.

Recent research at Sandia has suggested that the polarization of photons could be exploited to see better through fog or other scattering environments, David says.

Researchers have ideas about how to use optics — for example, a filter on a camera lens — to exploit polarization, he adds, but they need to be tested in a real-world environment, like the fog chamber.

Such testing could inform not only physical security camera design to better handle fog, but also medical imaging, he said. "The physics in scattering events are the same."

Hardware from legacy nuclear weapons: an invaluable teaching resource

By Sue Major Holmes

NUCLEAR WEAPONS MISSION — Retired Executive VP and Deputy Labs Director Jerry McDowell gives an impromptu talk to a Weapon Intern Program class that toured Sandia's Nuclear Weapon Legacy Hardware collection. Jerry spoke to the class shortly before his retirement, telling them the nuclear weapons mission requires a very big team and that it's vital for class members to get to know each other. (Photo by Randy Montoya)

Think of the new generation of nuclear weapons engineers and scientists as Sandia's Irish monks.

Retired Executive VP and Deputy Labs Director Jerry McDowell met Sandia's latest Weapon Intern Program (WIP) class in a vault that houses the Labs' newly created collection of legacy hardware from decades of nuclear weapons work. In an impromptu talk, he told the class about Thomas Cahill's "How the Irish Saved Civilization," the story of monks in a remote corner of Ireland during the Dark Ages in Europe preventing knowledge from disappearing by copying Christian and non-Christian manuscripts.

"While the rest of the world is spinning around, you are our Irish monks," said Jerry, nodding toward shelves of hardware in the warehouse-like vault. "We're going to look to you to preserve all this."

The Nuclear Weapon Legacy Hardware project is not a museum and is not open to all. It's a teaching resource to connect succeeding generations of nuclear weapons engineers to the engineering work of past generations. The WIP class Jerry met was the first class to see it.

"It's a collection to inspire and inform where we're going, not to admire where we've been," Jerry says.

The collection, years in the making, was initially proposed by John C. Hogan, retired senior Sandia scientist and former lead instructor for Sandia's weapon training programs. John, a senior mentor for WIP classes, started setting aside hardware about two decades ago. Throughout Sandia, various staff members held onto crates of legacy pieces, uncomfortable about their destruction, but unsure what to do with them.

"Each division or group was responsible for its own hardware, so as soon as a program ended, they could get rid of it or keep it," John says. In some cases, they kept too much; in others, they destroyed or discarded items without thought to the history of nuclear weapons development. John and Dave Tenorio (2916) started identifying hardware in 1998, the intern program's inaugural year. Sandia had hundreds of crates of material stored awaiting disposition.

Collection has been years in the making

A December 2007 letter to center directors with classified material prompted a study of Sandia's legacy hardware, including material at the Nevada Test Site, Tonopah Test Range, Kauai Test Facility, and Pantex. In 2013, the project was assigned to Weapon Engineering Professional Development Dept. 2916, which hired Pete Terrill to head the project and start putting the collection together. Dave was brought on as his deputy this year.

Jerry was in a position to provide resources to start the project. "It would have been a tragedy not to preserve that," he says. "As a teaching tool, it's extraordinary."

Manager John Whitley (2916) says the collection complements Sandia/New Mexico's Weapon Display Area and Sandia/California's National Security Resource Center, which focus on the current stockpile, by preserving generations of legacy hardware for study. "Tremendous amounts of knowledge are represented by this hardware, and being able to pick up and examine these legacy items can often greatly enhance learning over just studying archive drawings and reports," he says.

RETIRED EXECUTIVE VP and Deputy Labs Director Jerry McDowell (second from left) talks about the former BIOS program with, left to right, Pete Terrill, who heads Sandia's Nuclear Weapon Legacy Hardware project, and Weapon Intern Program senior mentors John C. Hogan and Al Hachigian. BIOS, which stands for Bomb Impact Optimization System, was a brief program in the mid-1990s. The bomb case is now part of Sandia's legacy hardware collection, which helps connect newer nuclear weapons engineers to the engineering work of the past. (Photo by Randy Montoya)

Pete rode his bike around Sandia searching for a building for the collection. He finally found a vault, in need of upgrading but suitable for the collection. The facility has been operating since October 2014 but is far from finished.

"It'll always be a work in progress," Pete says. The study identified more than 87,000 pounds of classified holdings. There still are boxes to unpack and items to identify. The empty north end of the building is destined for large, older nuclear weapons systems as they're added.

Just getting items ready can be challenging. Classification requirements have changed over the decades, so everything in the collection must be reclassified under today's guidelines. In addition, crates stored for years may lack detailed documentation about what's inside. That leads to exhaustive analysis, perhaps including X-rays to make sure they don't contain liquids or powders. "If something was stored decades ago, I guarantee our processes are a lot different today," Pete says.

John Hogan says disposing of unneeded hardware is just as important as preserving what should be saved. The savings in not having to store excess material and consolidating archival hardware into one building will easily pay for the project, he says.

Recollecting when the hardware was in use

Jerry, along with John and retiree and senior WIP mentor Al Hachigian, toured the vault with Pete and Dave shortly before Jerry retired. As they viewed items, John and Al mentioned former Sandians who might have information on various pieces, recalled when components were in use, told stories about the people who had them, and talked about how particular devices led to engineering solutions to problems, such as how to lock a switch into position.

"Al and John represent a powerful connection to the past from a teaching aspect," Jerry says.

The collection includes the first neutron generator designed by Sandia, a cylinder roughly a foot tall and about 8 inches in diameter, a giant by today's neutron generator standards. It includes a 1951 technical and specification manual for the first Sandia-designed nuclear weapon component, the first Sandia design of a fuzing radar system, and works of art by Sandia's former technical art department. The collection includes drawings and paintings dating as far back as the early 1950s.

"What amazing artists we used to have," said Jerry, looking at a 1957 Clyde Babcock drawing of Fat Man, the atomic bomb dropped on Nagasaki, Japan, in August 1945.

The archive offers examples of advanced concepts and innovative methods but also includes hardware that never made it into the stockpile because engineering chose a different design. It houses devices that led to a path to develop something safer. Some pieces are the first ever made of the particular item. Some are rare because few were ever made.

Archives also help recover legacy information

Some represent equipment still in use, such as refrigerator-size, vacuum pump-driven AMPEX reel-to-reel analog recorders at the front of the gallery.

"We still use those machines today to recover legacy flight test data from nuclear weapons Joint Test Assemblies and to recover data from legacy underground nuclear tests," says Gary Ashcraft (2662).

The reel-to-reel analog recorders were a telemetry range standard starting in the 1960s, although Gary's date from about 1984. "The machines didn't change too much over the years in their basic operation," he says. "Fifty years of the same technology says a lot about how well they were designed, and many companies made them." One 1-inch-wide 14-track tape can hold about 70 gigabytes of analog waveform data, which Gary calls "pretty impressive for the time."

Diane Miller (matrixed to 2916 from 3521) heads up another part of the program to preserve nuclear weapon knowledge, updating out-of-date tapes and other media to current formats. "We get them in these formats that are obsolete, and she digitizes it. She turns it from an old analog format so researchers can now pull it up and access this information," Pete says.

She uses old equipment — slide projectors and players for VHS, Betamax, cassette tapes, and videos — to copy information to convert to digital formats, CDs, and DVDs. "I go to Reapp [Property Management and Reapplication Dept. 10264] and grab what I can," she says.

Pete jokes about hanging around with the old guys who call him when they have something he might want.

"People retire and I get boxes of their stuff," he says. "My job is really going back in history and trying to trace the roots of a lot of this hardware."

PAUL AND BETH HOMMERT at their home in Corrales.
(Photo by Randy Montoya)

'My lab can do this'

Paul Hommert reflects on five years as Sandia president and Labs director

PAUL HOMMERT with Secretary of Energy Ernest Moniz.
(Photo by Randy Montoya)

Story by Bill Murphy

Maybe if that cold winter wind hadn't been blowing off Lake Erie when Paul Hommert interviewed for a job in Buffalo back in 1973, his career might have taken a completely different course.

LAND OF ENCHANTMENT — Paul Hommert and his wife Beth moved to New Mexico after Paul accepted a job offer from Sandia upon completing his PhD from Purdue.
(Photo courtesy of Paul Hommert)

PAUL HOMMERT answers a question from a reporter during a news conference announcing the transition in leadership at Sandia. Tom Hunter, at left, passed the reins as Sandia president and Labs director to Paul in July 2010. (Photo by Randy Montoya)

IN TESTIMONY before the Senate Armed Services Committee's Subcommittee on Strategic Forces in 2014, Paul Hommert outlined the Labs' nuclear weapons mission work. (Photo by Charles Votaw)

There he was, a master's degree in mechanical engineering from Purdue University in hand, ready to start his professional career. He'd interviewed with a number of firms, got a few offers, but nothing felt quite right to him.

He particularly remembers the company in Buffalo, New York, that was interested in him. "It was sort of a bizarre recruiting technique," Paul says with a laugh. "Interviewing a job candidate in Buffalo? In January? After going through the interview, I thought 'Nah, maybe not.'

"That was actually one of the final straws that made me decide to stay at Purdue and get a PhD."

Three years later, in 1976, the market for engineers with advanced degrees had tightened up and although he had several interviews, only Sandia stepped forward with a formal job offer.

"I took the job and was happy to get it," he says. "Sandia was by far doing the most interesting work. Even if I'd had five other offers, this was the one I would have prioritized because it looked to me like they were doing stuff nobody had done before. That was true then and it's still true."

Paul's interest in engineering came early. As an adolescent and teenager growing up in Huntington, Long Island, in the 1960s, his imagination was fired by the nation's space program; he knew the details of every mission, the names of every astronaut, and which missions they had flown. But unlike a lot of kids his age, Paul didn't dream of becoming an astronaut. It was the work in Mission Control that inspired him.

"I really wanted to understand how this stuff worked. It seemed to me that engineering was the best way to learn."

IN 2010, EARLY IN HIS TENURE as Sandia president and Labs director, Paul Hommert completed a milestone event, fulfilling one of the key responsibilities he assumed with his new job: the signing of the Annual Assessment letter. As required by law, each year, based on the findings of their respective stockpile surveillance programs, the directors of the three NNSA laboratories (Sandia, Los Alamos, and Lawrence Livermore) submit letters to the secretaries of Energy and Defense reporting on the assessment of the stockpile. The secretaries, in turn, submit a letter to the president under their signatures detailing the state of the nation's nuclear deterrent. (Photo by Randy Montoya)

A few surprises

Once on roll at Sandia, Paul's leadership skills were apparent early on and over time he assumed positions of increased responsibility in a broad range of programs and management assignments. As a technical manager, he says he sometimes missed the day-to-day practice of engineering buts adds that "I feel that I'm better at what I'm doing than I was as a hands-on engineer."

By the time he became Labs director, Paul had been immersed in the Sandia culture for decades, but there were still a few things that caught him by surprise.

"Until you sit here you don't fully appreciate the diversity of issues requiring a decision that end up in this office. It runs an extraordinary gamut from mission delivery, to legal matters, to personnel. Sometimes you wonder, 'Do I really have the training to deal with this?' because even though you get great advice from the leadership team, in the end you have to make the call."

Paul says, too, that as a leader with an impatience to drive things he didn't always appreciate the importance of taking a measured, deliberate approach in implementing change. "Total Comp is a good example," he says. "It was a very deep, important, and complex change that had many dimensions from the details, to the cultural components, to the communications requirements — and we didn't get it right out of the box." A more deliberate approach, Paul suggests, would have served the Total Comp deployment better. And there were other challenges where a similar approach would have helped.

A passion for safety

"In our safety journey, for example," Paul says, "if I knew then what I know now, if I'd recognized more fully the depth of the cultural challenges involved in what we were trying to do, I would have used some of my personal time differently. For example, I wish I had personally carried the message about the importance of safety to all levels of management sooner in my tenure."

As Labs director, few things figured larger in Paul's thinking than safety. He and his leadership team developed what he describes as an "intellectually rigorous" framework for engineered safety. It is a framework, he says, "that can speak to our workforce, many of whom have been taught to question things. If you give them things that they feel are dominated by compliance rather than by critical thinking, you're not starting in the right place. Compliance is important, but it's there to support critical thinking."

"With this framework in place, and with the example of leadership, what I hope will happen someday — and I believe we're getting there — is that every employee recognizes that they've come to a place where our passion for safety is a matter of pride just as much as any mission delivery that we make because they're inseparable."

'My lab can do this'

In a tenure marked by notable accomplishments, many of which can't be discussed openly, Paul says the on-going execution of the life extension programs — LEPs — for weapon modernization is the most significant both because of the scope of the challenges and their sheer scale.

"You can best capture the sense of what Sandia is capable of by looking at how we've executed this tremendously large program involving thousands of people throughout the Labs," he says.

Paul notes that early on in the current LEP era, not all the stakeholder community had the confidence that Sandia could deliver. "There was a lot of skepticism," he says. "Something I will always carry with me is that in many venues, very senior venues, I was able to say without a moment's hesitation 'My lab can do this,' because I knew the passion and the talent of the people here. And we're doing it. Every day there are hiccups on programs of that complexity but we work our way through them. It's put the laboratory in a very strong position both with respect to our core work in the weapon program and in the message it sends about the Labs' capabilities more broadly and the confidence people have in the laboratory."

Unique access

If the role of Labs director has its challenges and frustrations, it also offers some unique rewards. For example, Paul says he has appreciated the opportunity to participate in venues where key national security topics are discussed, to have access to senior leadership at the Cabinet level and in Congress and to find "they actually listen to you; maybe they don't do what you suggest, but they listen to you. You only have that access because you lead an institution of such reputation and importance."

Also especially rewarding, Paul says, "is the chance to just represent our achievements. I get to give a lot of talks here and there and people supply me with material and I can say we did this, we did this, and we did this. Audiences are always impressed with the scope of our mission work. That's fun."

Closer to home, Paul enjoys going around the Labs meeting people who are doing phenomenal things. "And I don't mean just technical things. I mean in the way they support our logistics, our communications, our business operations, and HR — there's such passion and sense of feeling good about the place they work. There's that sense of achievement and community and it's very rewarding. Getting to see this laboratory from such a comprehensive perspective is very special."

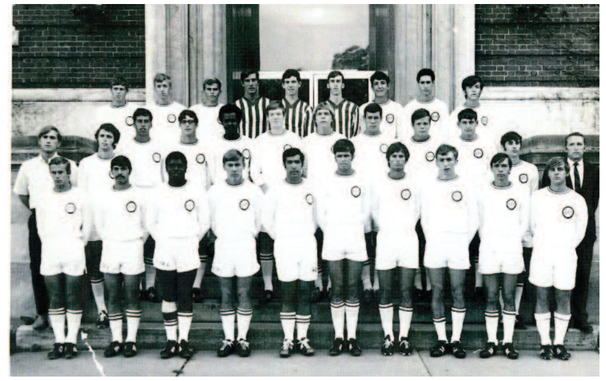
Committed to national security

As Paul transitions into retirement, he says his first priority, after years of near-constant travel conducting Labs business, will be to spend more time with his wife, Beth, and his children and grandchildren. Maybe follow a couple of his favorite sports teams more closely. Maybe take a winemaking class to enhance his knowledge about and appreciation of his own modest wine collection.

"Having said that, I remain passionately committed to national security," Paul says, "I think there's room between 100 mph and just sitting on the couch and I hope to have a few roles where I can continue to contribute in ways that have a different life/work balance than I have today. . . . I'd like to stay engaged in some capacity, particularly to delve deeper into the intersection of technology and public policy."

After five years at the helm of the nation's largest Federally Funded Research and Development Center, Paul says he is ready to move on to the next phase in his life. Preparing to pass the torch to a new leader, Paul says, "As I leave, I'd like to think that Sandia sees itself as a more integrated laboratory, as a laboratory where its leadership is more connected at all levels, where its values are more evident in the way we work and operate, where everyone has a greater sense of sharing in our collective accomplishments, because we are more integrated.

"I leave the lab with a hope that because we had to weather some tough stuff together — pension funding challenges, pay freezes, shutdowns — maybe there's a sense that our people know that their leadership truly cares and is motivated by the desire to do what's best for this laboratory, our people, and the nation. And I hope, too, that everyone here knows that what we do for the nation truly matters."



AS AN UNDERGRAD, Paul played for the Rensselaer Polytechnic Institute soccer team. In this photo from 1969, Paul is third from the right in the bottom row. (Photo courtesy of Paul Hommert)

WHILE SERVING as Div. 8000 VP in 2008, Paul Hommert visits with members of the workforce during the kickoff celebration for the California site's annual SHARE campaign. (Photo by Randy Wong)

PAUL AND BETH HOMMERT sit for an informal family photo with their children and grandchildren.
(Photo courtesy of Paul Hommert)

Sandia's Z machine receives funding aimed at fusion energy

Laser beam 'smoothing' with U of Rochester to play key role

By Neal Singer

A $3.8 million, two-year grant to Sandia and the University of Rochester's Laboratory for Laser Energetics (LLE) is expected to hasten the day of fusion break-even and eventually high-yield for energy production.

The grant was announced by DOE's Advanced Research Projects Agency for Energy (ARPA-E).

Previous fusion work at both institutions had been funded by DOE's National Nuclear Security Administration (NNSA) solely to support the Stockpile Stewardship Program, whose goal is to maintain a safe and reliable nuclear deterrent without nuclear testing.

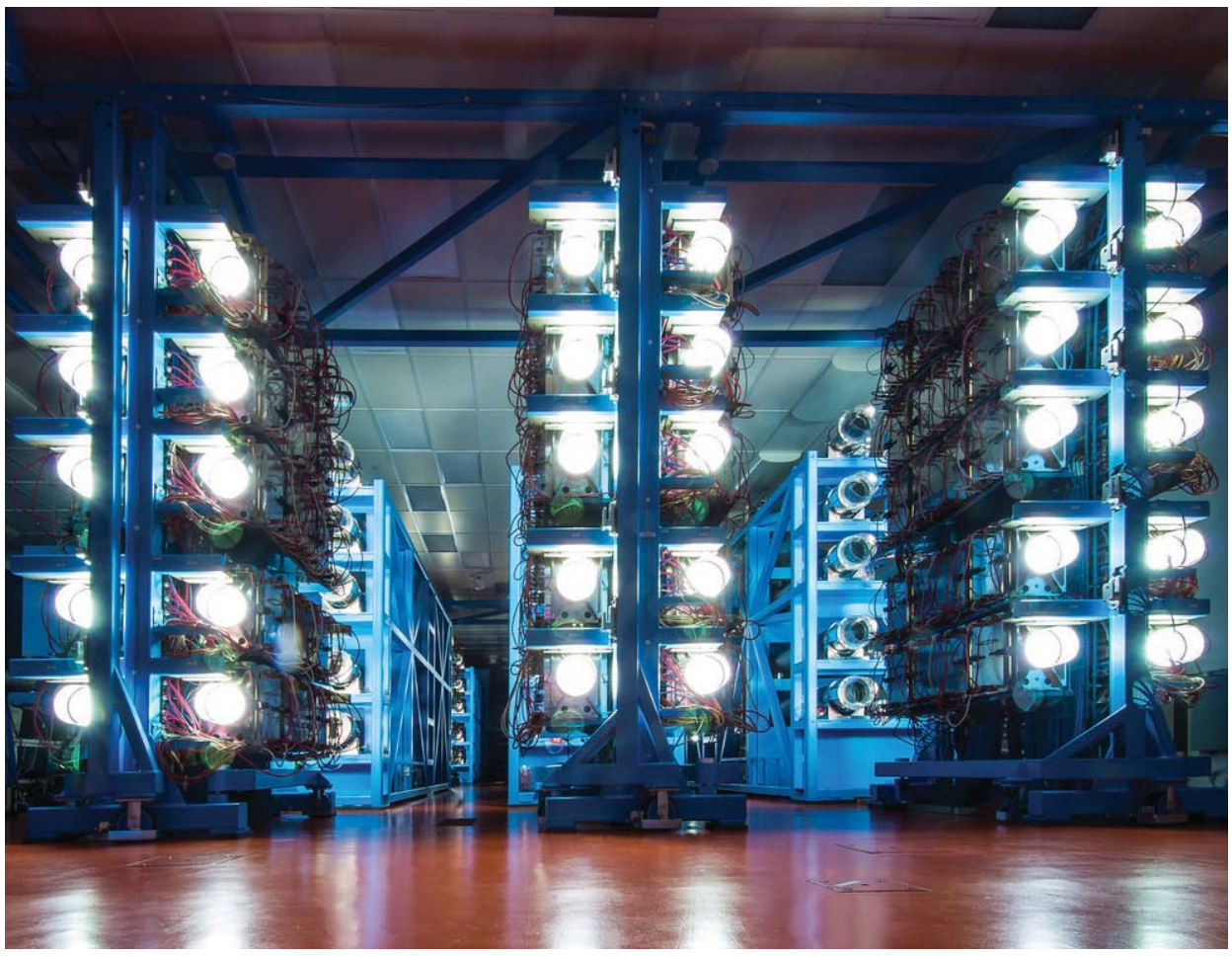
Break-even means as much energy emerges from a fusion reaction as is put into it; high-yield means that much more energy emerges.

The work to be conducted at both laboratories is expected to advance a promising Sandia energy concept called MagLIF, for Magnetized-Liner Inertial Fusion.

Originally proposed in a 2010 theoretical paper by Sandia researcher Steve Slutz (1684) and colleagues, the concept uses a laser to heat fusion fuel contained in a cylinder, called a liner, as that cylinder itself is compressed by the huge magnetic field of Sandia's massive Z accelerator. A secondary axial magnetic field embedded in the fuel and cylinder impedes the laser energy from escaping the resultant plasma, which would lower the temperature of the fuel and reduce the fusion output.

The combined heat and pressure, created by the laser preheating and liner imploding over a hundred or so nanoseconds, have been shown to force fuel to fuse in recent experiments on Z. The next step is to force it to fuse more efficiently and, at the same time, allow researchers to learn more about important physical mechanisms at work.

ARPA-E's bet, and Sandia's and Rochester's with it, is that a more efficient coupling of the laser energy to the fusion fuel will increase the number of neutrons produced, the gold standard in judging the efficiency of the fusion reaction.



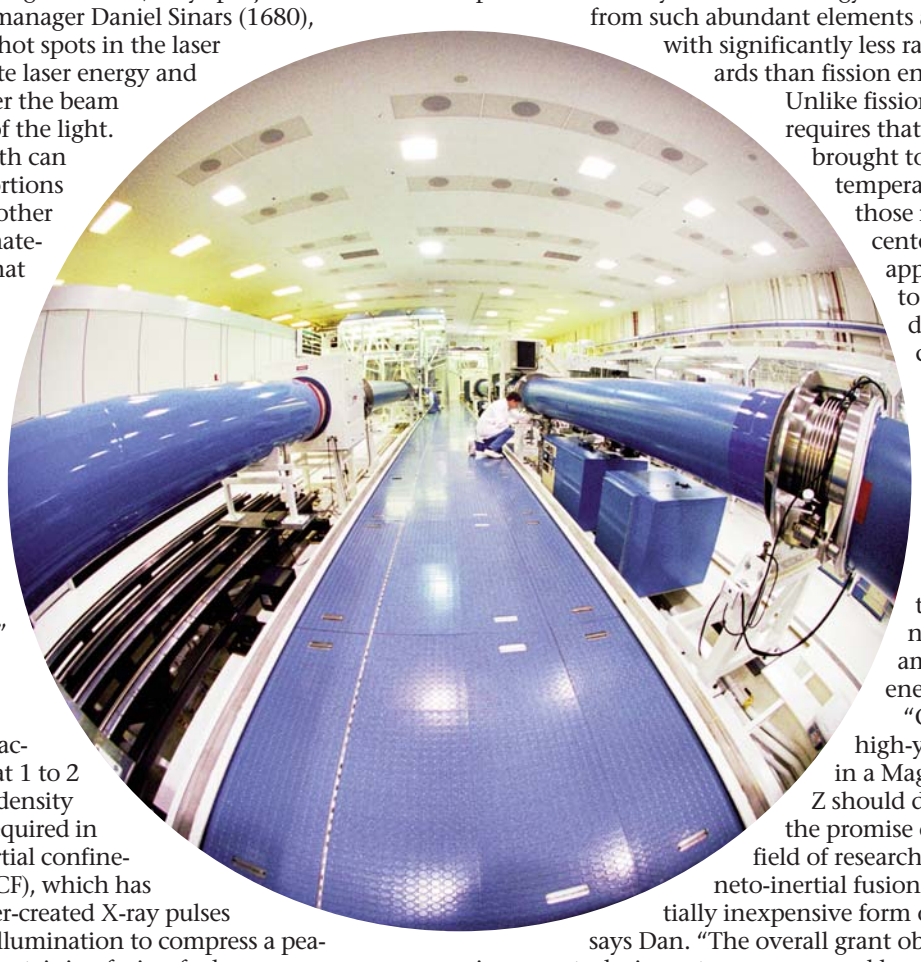
TWENTY-CENTIMETER DISK AMPLIFIERS (above) used to energize 60 laser beams glow brightly at the 100-meter-long OMEGA laser at the University of Rochester's Laboratory for Laser Energetics, while (below) amplified light passes through the large tubes of Sandia's Z-Beamlet laser, one of the most powerful in the world. Both lasers will experiment with more efficiently preheating fusion fuel to improve the output of Sandia's MagLIF (Magnetized Liner Inertial Fusion) technique.

(Top photo courtesy of University of Rochester; bottom photo by Randy Montoya)

Smoothing laser beams

As it happens, scientists at the LLE over many years have developed techniques to "smooth" laser beams, a prerequisite for delivering more energy to fusion fuel.

"By smoothing the beam," says project lead and Sandia senior manager Daniel Sinars (1680), "we eliminate hot spots in the laser beam that waste laser energy and potentially alter the beam path of some of the light. This altered path can disintegrate portions of the liner or other surrounding material. Some of that material then may contaminate the fuel and increase radiation losses, causing the fuel temperature to collapse below that needed for fusion reactions to occur."



When optimized, the process should allow fusion reactions to occur at 1 to 2 percent of the density and pressure required in traditional inertial confinement fusion (ICF), which has used either laser-created X-ray pulses or direct laser illumination to compress a pea-sized capsule containing fusion fuel.

Says professor and LLE director Robert L. McCrory, "The ARPA-E award will fund research that will benefit from the existing strong collaborative effort between Sandia National Laboratories and LLE." The two institutions already have traded scientific knowledge and laser components in pursuit of the grand challenge of laboratory-scale fusion. "LLE, with its 60-beam OMEGA and 4-beam high-energy OMEGA-EP lasers, and Sandia, with the world's largest pulsed-power machine at Z, provide unique capabilities to explore a range of fusion parameters previously unexplored," he says.

Nuclear fusion joins small atoms like hydrogen, releasing huge amounts of energy in the process. Unlike nuclear fission, which splits large atoms such as uranium, the dream of fusion is that it eventually could provide humanity unlimited energy from sea water and from such abundant elements as lithium with significantly less radioactive hazards than fission energy.

Unlike fission, fusion requires that matter be brought to enormous temperatures such as those found in the center of stars, approximately 50 to 100 million degrees. The challenge of fusion is to create matter at such temperatures at high enough pressures and for long enough times to release significant amounts of energy.

"Creating a high-yield reaction in a MagLIF plasma at Z should demonstrate the promise of the broader field of research we call magneto-inertial fusion — a potentially inexpensive form of fusion," says Dan. "The overall grant objective is to improve techniques to compress and heat intermediate-density, magnetized plasmas, as well as to provide insights into relevant energy losses and instabilities. We hope that the results of our research will successfully motivate more investment by the Department of Energy and private companies in this field."

An advantage of laser heating is that ideas involving lasers can be tested on multiple facilities across the country, allowing a much larger number of tests per year than is possible on the unique Z facility.

> *"If the small-scale MagLIF experiments are successful and accurately modeled, we will have demonstrated magneto-inertial fusion principles over a very broad range of energy, space, and time scales."*
>
> **— Jonathan Davies**

"It should easily be possible to do more than 200 laser shots a year split among the Z-Beamlet, OMEGA, and OMEGA-EP facilities, in contrast to the two dozen or so integrated MagLIF experiments a year realistically possible on Z," Dan says.

A new path in fusion research

The LLE's OMEGA laser, funded and operated as a national user facility with more diagnostics than Z's Beamlet laser, is expected to greatly speed the work. "OMEGA can fire 12 times per day and can also provide better diagnostic access," says Jonathan Davies, a research scientist and leader of the effort at LLE. "The ARPA-E project will bring together the resources of Sandia and the LLE to work on the same project with completely different techniques."

Integrated laser experiments, where 40 of OMEGA's 60 beams are used to compress the liner as well as heat the magnetized fusion fuel it contains, are also part of the ARPA-E program. "These experiments will allow us to study MagLIF on a much smaller scale and at a faster rate than on Z," says Davies. "If the small-scale MagLIF experiments are successful and accurately modeled, we will have demonstrated magneto-inertial fusion principles over a very broad range of energy, space, and time scales."

The collaboration will study fusion in a relatively unexplored intermediate density regime between the lower-than-air density of magnetic confinement fusion, which uses magnetic field to contain fusing plasma, and the greater-than-solid density of ICF, which uses X-rays or direct laser illumination to crush pellets of fusion fuel over times less than a billionth of a second. "With this collaboration, we will apply our expertise to explore a new path in fusion research," Davies says.

The work will consist of four parallel efforts: achieving fuel pre-heating; determining whether MagLIF can reach fusion conditions on Z and on the OMEGA laser; and validating simulations against experiments.

After 38 years, Mike Vahle steps down

By Neal Singer

When Div. 9000 VP Mike Vahle retires on July 14, his latest hat — that of Chief Information Officer — will be only the last of many this unassuming man has worn in his 38 years at Sandia. His experiences lend a certain authority to his judgments.

Mike accepted his CIO post four years ago because he was interested by the challenges posed by cyber-hacking. "It's certainly a growing threat," he says, "but we found a way for Sandia to practice its talents and improve its wares.

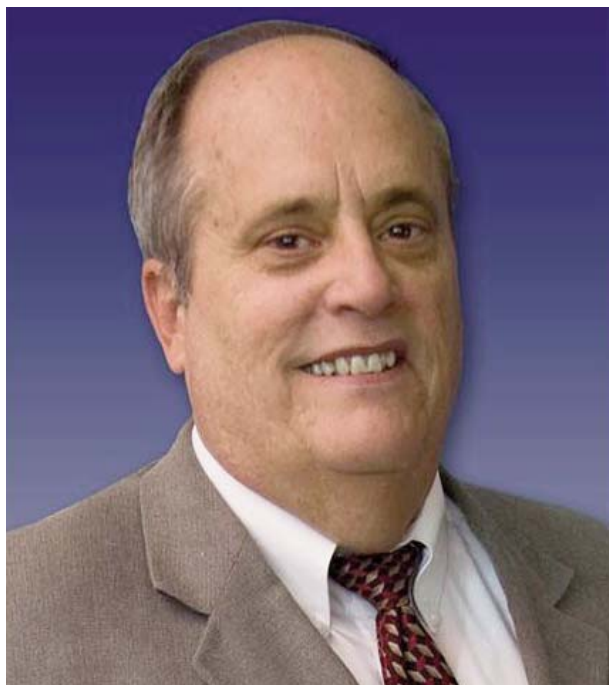
"We borrowed people and technologies," he continues, "as we gained an operational perspective; then we funded a program test bed. Judging by the people who have been willing to come over and work in the cyber program — and their successes — it's proven to be a quite valuable project."

Overall, he says, "My biggest surprise since putting on the CIO hat is the magnitude of how important these computer systems are to the Labs. They're part of every program." And Sandia's corporate computing infrastructure continues to evolve, he says. "I tried to recapture our early spirit of innovation, and the network, applications, and processes we have in place are becoming state of the art again."

No stranger to supercomputers, Mike previously worked as a director running the ASCI program for former Labs director Tom Hunter, which produced, among other successes, the revolutionary Red Storm supercomputer. "We developed a robust, well-funded program that delivered software and machines that implemented modeling at the national scale for nuclear weapons," he says.

Groups he sponsored answered the questions of "how do you validate and verify codes, and how do you embed it in the engineering process."

He worked on the project with people whose names have a certain ring at Sandia: Ed Barsis, Jim Tomkins, Marty Pilch, Tom Bickel, "and of course Bill Camp."



MIKE VAHLE

"Personally, that was an opportunity to see the entire nuclear weapons program. I learned how you make tradeoffs doing one thing or another, and how to defend stockpile simulation in a national debate."

The influential Jasons — an independent group of scientists that advises the US government on science and technology — were skeptical of the technology, Mike says, but a series of studies helped convince them of the value of simulations and Sandia's physical capabilities in determining the health of the stockpile.

Asked about the possibility that researchers in an unfriendly country might analyze the US nuclear stockpile and inform their political leaders that the American weapons — tested in the last 24 years only by computer simulations and subcritical tests — would fail if used, Mike nods thoughtfully and then comments dryly, "That'd be a mistake."

A stint directing the Systems Mission Engineering center along with the Space Mission Program in the Defense Systems and Assessments Strategic Management Unit immersed Mike in another can-do culture. "Working in Sandia's space program provided experiences comparable in many regards to that of NW," he says. "Challenging problems, incredible national impact, and a culture of technically expert people." And once again he names the people: Jerry McDowell, Dennis Ellers, Bruce Swanson, Larry Ellis, and Steve Lott "to name only a few."

Other jobs worked successfully by Mike were less dramatic but held their own importance. "I was a team member on a project in 1977 that built the first data network at Sandia," he says. "This was before the Internet. We used DEC technology and hardware that had to be developed at Sandia.

"That group brought a lot of new technology to the Labs. For instance, we implemented the first central office electronic switching system outside Ma Bell."

That was important, he says, because obtaining telephone service on base was unpredictable and unreliable. "It took months to get help, and it was worse if you switched offices. This switch — the 5ESS, it was called — gave us control of our own destiny."

What will he miss most? "The continuous stream of challenges, and the people you get to work with to solve them," he says. "I mark my career with whom I interacted at the time." He mentions Mike Eaton, Pace Vandevender, Steve Gossage, and others. "I'll have to find another measure."

He looks forward to spending time with his wife, children, and grandchildren, and finding out what's new and exciting in the world of mathematics, the subject in which he majored in college and which still calls to him.

Recent Patents

Note: Patents listed here include the names of active and retired Sandians only; former Sandians and non-Sandia inventors are not included. Following the listing for each patent is a patent number, which is searchable at the US Patent and Trademark Office website (www.uspto.gov).

* * *

Murat Okandan (1719): Method of Forming Through Substrate VIAS (TSVs) and Singulating and Releasing Die Having the TSVs from a Mechanical Support Substrate. Patent No. 8,906,803.

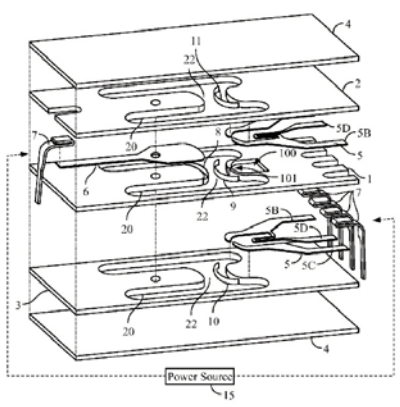
Shawn M. Dirk (2735), Robert Boye (1728), Michael R. Descour (1725), William C. Sweatt (1516), David R. Wheeler (5964), and Bryan James Kaehr (1815): Method to Create Gradient Index in a Polymer. Patent No. 8,859,190.

Nathan J. Edwards (5956), Jason Hamlet (5627), Todd Bauer (1746), and Ryan Helinski (5627): Increasing Security in Inter-Chip Communication. Patent No. 8,874,926.

Paul Davids (1765) and David W. Peters (1765): Frequency Selective Infrared Sensors. Patent No. 8,897,609.

Hongyou Fan (1815): Synthesis of Porphyrin Nanostructures. Patent No. 8,871,926.

Jon Ihlefeld (1816), Paul G. Clem (1816), David Ingersoll (2500), Ganesan Nagasubramanian (2545), and Kyle Ross Fenton (2545): Solid-State Lithium Battery. Patent No. 8,877,388.



Patent No. 8,891,721

Juan M. Elizondo-Decanini (2624): Neutron Generators with Size Scalability, Ease of Fabrication, and Multiple Ion Source Functionalities. Patent No. 8,891,721.

Juan M. Elizondo-Decanini (2624): Detonator Comprising a Nonlinear Transmission Line. Patent No. 8,922,973.

Jeffrey Pankonin (5353), Richard E. Heintzleman (5353), and Nicola Jean Kinzie (5352): Ultra-Wideband Short-Pulse Radar with Range Accuracy for Short Range Detection. Patent No. 8,854,254.

Randolph R. Kay (1753), David V. Campbell (1767), Subhash L. Shinde (6123), Jeffrey L. Rienstra (5774), Darwin K. Serkland (1766), Michael L. Holmes (1753), Seethambal S. Mani (2735), Dahwey Chu (1718), and Thomas Gurrieri (1753): Focal Plane Array with Modular Pixel Array Components for Scalability. Patent No. 8,907,439.

Kurt W. Larson (5563), and Jason W. Wheeler (6533): Fast Electron Microscopy via Compressive Sensing. Patent No. 8,907,280.

Jason R. Hamlet (5627), and Lyndon G. Pierson (Ret.): Multi-Factor Authentication. Patent No. 8,868,923.

Lyndon G. Pierson (Ret.), Edward L. Witzke (6525), Thomas D. Tarman (5643), Perry J. Robertson (1751), John M. Eldridge (5632), and Philip L. Campbell (5629): Stateless and Stateful Implementations of Faithful Execution. Patent No. 8,914,648.

Michael V. Bredemann (5773): Reducing Current Reversal Time in Electric Motor Control. Patent No. 8,878,473.

Hung Loui (5345), James Carroll (5964), Paul G. Clem (1816), and Michael B. Sinclair (1816): Resonant Dielectric Metamaterials. Patent No. 8,902,115.

Peter Marleau (8127), Erik Brubaker (8127), and Scott Kiff (8127): Time Encoded Radiation Imaging. Patent No. 8,866,100.

F. Patrick Doty (8126), Mark D. Allendorf (8300), and Patrick L. Feng (8126): Doped Luminescent Materials and Particle Discrimination Using Same. Patent No. 8,853,651.

Mark D. Allendorf (8300) and Alex L. Robinson (2632): Materials, Methods, and Devices to Detect and Quantify Water Vapor Concentrations in an Atmosphere. Patent No. 8,904,850.

Alfredo M. Morales (8126), Richard J. Anderson (Ret.), Nancy Y. C. Yang (8341), and Michael J. Rye (1819): Method to Fabricate Micro and Nano Diamond Devices. Patent No. 8,852,998.

Jeffrey P. Koplow (8366): Power Selective Optical Filter Devices and Optical Systems Using Same. Patent No. 8,854,713.

Anson V. Hatch (8621), and Anup K. Singh (8620): Methods, Microfluidic Devices, and Systems for Detection of an Active Enzymatic Agent. Patent No. 8,871,496.

Anup K. Singh (8620): Dielectrokinetic Chromatography Devices. Patent No. 8,911,606.

H. Lee Ward (1423), and Anand Ganti (9336): Design, Decoding, and Optimized Implementation of SECDED Codes over GF(q). Patent No. 8,892,985.

Yongliang Xiong (6212), and Yifeng Wang (6222): Advanced Fire-Resistant Forms of Activated Carbon and Methods of Adsorbing and Separating Gases Using Same. Patent No. 8,945,277.

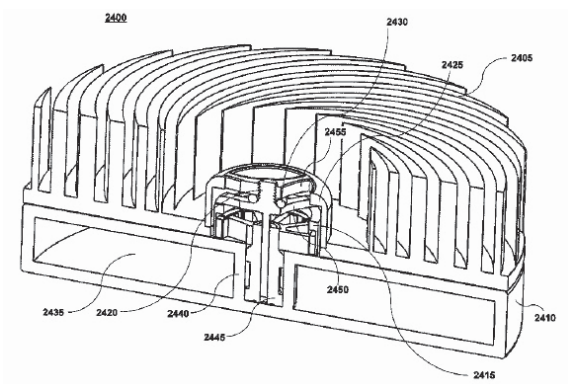
Andrew Vance (8221), Greg O'Bryan (8223), and Elaine Lai Yang (8242): Carbon Nanotube Composite Materials. Patent No. 8,986,576.

David G. Wilson (1353): Computing an Operating Parameter of a Unified Power Flow Controller. Patent No. 8,930,034.

Jason R. Brown (1852): Detection of Gas Leakage. Patent No. 8,955,370.

Chung-Yan Koh (8621): Devices, Systems, and Methods for Conducting Assays with Improved Sensitivity Using Sedimentation. Patent No. 8,962,346.

Anup K. Singh (8620) and Anson Hatch (8621): Devices, Systems, and Methods for Conducting Sandwich Assays Using Sedimentation. Patent No. 8,945,914.



Patent No. 8,988,881

Jeffrey P.Koplow (8366): Heat Exchanger Device and Method for Heat Removal or Transfer. Patent No. 8,988,881.

David F. Aldridge (6913): Elecrically Conductive-Proppant and Methods for Detecting, Locating and Characterizing the Electrically Conductive Proppant. Patent No. 8,931,553.

Employee death

Strong, fearless, full of love, and bigger than life: Colleagues remember Kalina Jinzo

Kalina Jinzo, 40, died May 22 from injuries she suffered after being struck by lightning on May 10 while riding as a passenger on a motorcycle near Ruidoso, New Mexico. Kalina (3334), a medical assistant in Sandia's Health Management Clinic for the past eight years, is remembered by her colleagues as a life-loving bundle of energy who was the "go-to" person if something needed to be done.

KALINA JINZO

"What a huge personality to try to sum up in a few words," says one former colleague, adding that there was a story about Kalina that goes to the heart of who she was as a person.

As her friend recounts it, Kalina was on her way home from work one evening when she came across a woman poised at the edge of a railing on an overpass above the interstate. Recognizing that the woman was about to jump, Kalina pulled over to the shoulder and ran to the woman to talk her down. At one point, Kalina was actually hanging over the edge herself, holding the woman to keep her from falling. Kalina finally pulled the woman away from the railing, away from certain death, and sat on her until the police arrived.

"That was Kalina," the friend says. "She gave love wholeheartedly and was always taking care of others."

Recalls Kalina's manager, Renee Holland (3334), "It was great working with Kalina. She had a personal passion for her job, was a hard worker, and a key contributor to Sandia's employee wellness programs. Our patients loved her because they knew she genuinely cared about them."

Many of Kalina's colleagues wanted their recollections about their friend to be presented collectively. Among those sharing thoughts were Johanna Grassham (3334), Pete DelMarcelle (3331-1), Dr. Rick Sauerman (3331), Dr. Deborah Grady (3334), Cristina Armijo (3331-1), Liz Diaz (3331), Callie Lovato (3334), and Angelique Crandall (3334).

"Kalina was always the life of the party and was just so much fun to be around," says one friend.

Fun, yes, and super-competent, but also determined and strong-willed, Kalina had strong views about how things should be done and didn't mind letting people know what she thought.

"Kalina was one of a kind," says a colleague who worked side by side with her for years. "I'm thankful she was a part of our lives because she made us better, stronger, and a little feistier."

"It's extremely difficult to accept the fact that she's gone," says another, and, addressing her thoughts directly to her departed friend, says, "Kalina, your presence was always known, because you were just that loud! You really lived life to the fullest and enjoyed every moment. You were strong-willed, fearless, straightforward, vivacious, free-spirited, bold, family-oriented, God-fearing, caring, and a great cook."

"Kalina was an amazing, one-of-a-kind friend and coworker who will never be forgotten," says another friend. "When Kalina entered the room, everybody knew it. She was bubbly, energetic, and full of life. She had a huge smile and a laugh that was infectious. Kalina had more life in her than most people, which makes it harder to accept that she is gone and we won't see her running down the halls, lighting fires under all of us, and making jokes left and right."

Kalina had a sharp, sometimes sarcastic sense of humor, but she was never mean-spirited in her ribbing.

"I just took for granted that she would always be there, part of our group, laughing and either stirring up some queso or stirring the pot, in a fun sort of way," remembers a friend.

"It seems clear now that Kalina was not going to go out with a whisper some day in the far-off future reflecting on things she wished she could have done in her life. Not Kalina Jinzo. Kalina was going to leave us while riding through a desert storm with a bolt of lightning and a thunderclap. That's probably how she came into the world."

Kalina, for all her free-spirited ways, was orderly to a fault, with a passion for cleanliness and an attention to detail. And she was a role model for her younger colleagues. She would never sweat the small stuff and seemed to never have a bad day.

"I admired that she took care of herself and everyone else," says one, "always cooking, directing, and caring for everyone. She did all her own home painting and even put in her own wood floors. She was my hero!"

On reflection, one friend says she is not surprised by the details of Kalina's untimely passing.

"The thing I keep going back to in my mind is that Kalina was teaching us all along," she says. "How to be happy, how to be fearless, how to give.

"It seems clear now that Kalina was not going to go out with a whisper some day in the far-off future reflecting on things she wished she could have done in her life. Not Kalina Jinzo. Kalina was going to leave us while riding through a desert storm with a bolt of lightning and a thunderclap. That's probably how she came into the world.

"Still, she was teaching even then. Teaching us to take nothing for granted and that each day of life is precious and without a guarantee. And for us to take care of one another."

Kalina is survived by her three children, her parents, a grandfather and grandmother, a sister, and many aunts, uncles, cousins, and other family members.

— Bill Murphy

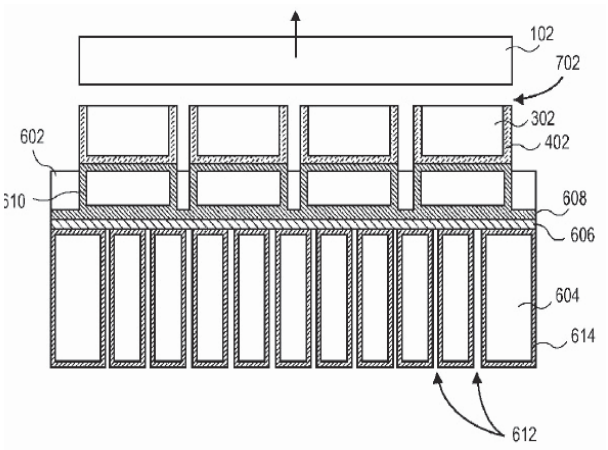
Recent Patents

Note: Patents listed here include the names of active and retired Sandians only; former Sandians and non-Sandia inventors are not included. Following the listing for each patent is a patent number, which is searchable at the US Patent and Trademark Office website (www.uspto.gov).

* * *

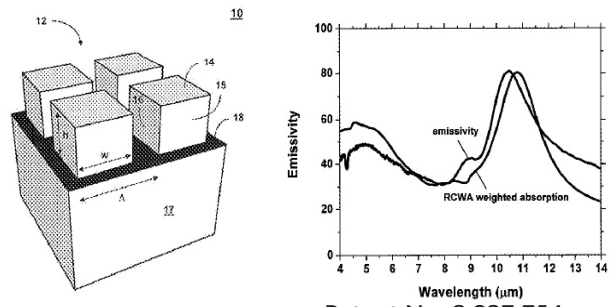
Hayden James Evans McGuinness (1725), Grant Biedermann (1728), and Akash Rakholia (1728): High Data-Rate Atom Interferometers Through High Recapture Efficiency. Patent No. 8,941,053.

Jeffrey G. Cederberg (1126), Paul J. Resnick (1719), Carlos Anthony Sanchez (1747), and Anna Tauke-Pedretti (1766): Processes for Multi-Layer Devices Utilizing Layer Transfer. Patent No. 8,946,052.



Patent No. 8,946,052

Paul J. Resnick (1719), David Bruce Burckel (1765), Paul Davids (1765), and Bruce L. Draper (1768): Membrane Projection Lithography. Patent No.8,981,337.



Patent No. 8,987,754

Eric A. Shaner (1118), David W. Peters (1765), and Paul Davids (1765): Highly Directional Thermal Emitter. Patent No. 8,987,754.

George T. Wang (1126): Method of Fabricating Low-Dislocation-Density Epitaxially-Grown Films with Textured Surfaces. Patent No. 8,932,403.

Anup K. Singh (8620), and Daniel J. Throckmorton (8625): Microchannel Gel Electrophoretic Separation Systems and Methods for Preparing and Using. Patent No. 8,961,766.

Michael Bartsch (8625), James L. Van De Vreugde (8625), Kamlesh Patel (8625), and Ronald F. Renzi (8625): Microfluidic Hubs, Systems, and Methods for Interface Fluidic Modules. Patent No. 8,940,147.

Tina M. Nenoff (1100): Mixed-Layered Bismuth-Oxygen-Iodine Materials for Capture and Waste Disposal of Radioactive Iodine. Patent No. 8,926,870.

Arlyn J. Antolak (8126): Plasma-Driven Neutron/Gamma Generator. Patent No. 8971473.

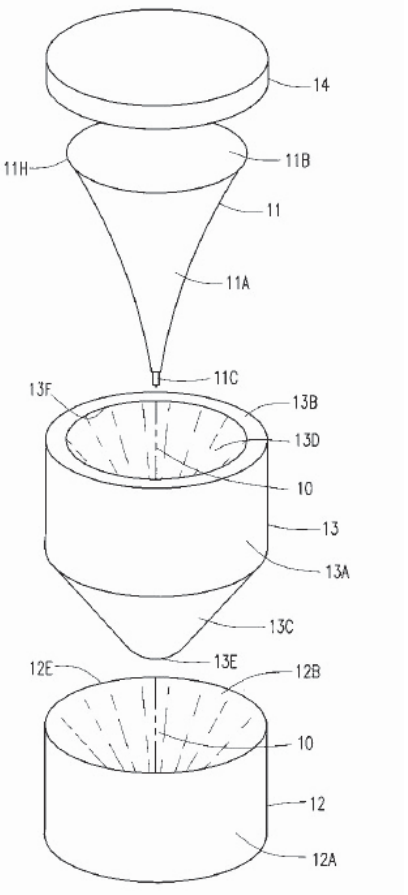
C. Jeffrey Brinker (1000): Protocells and Their Use for Targeted Delivery of Multicomponent Cargos to Cancer Cells. Patent No. 8,992,984.

Timothy J. Boyle (1815): Synthesis of PD Nanoparticles by Alcohols-Assisted Photoreduction for Use in Supported Catalysts. Patent No. 8,962,512.

Timothy P. Bielek (5342), and Douglas L. Bickel (5344): Synthetic Aperture Radar Images with Composite Azimumth Resolution. Patent No. 8,994,577.

Christopher DeRose (1765), and William A. Zortman (5645): High-Speed Photonic Modulator Designs. Patent No. 8,947,764.

Travis Wayne Eubanks (5345), and Christopher L. Gibson (5352): Ultra-Wideband, Omni-Directional, Low Distortion Coaxial Antenna. Patent No. 8,928,546.



Patent No. 8,928,546

Sandia Classified Ads

MISCELLANEOUS

LEATHER COUCH, top grain, 90" x 40", nail head, maroon/burgundy, $500 OBO. Hennessey, 505-269-6243.

STORM DOOR, w/doggie door, $40; Igloo dog house, $20; World Market solid wood tables (1 coffee, 1 end), $50; prices negotiable. Brewer, 505-459-3870.

SIDEBOARD BUFFET TABLE, beautiful, light/medium golden brown, excellent condition, photos available, $125. de la Fe, 903-0717.

BARI SAX, low Bb, $900; drum kit, Sunlite, $250; Wii console, controllers, games, $150. Tucker, 505-883-4041.

'STAMPIN' UP', stamps & supplies, in lots/boxes only, no individual stamps. Kaplan, 505-298-7953.

SKYLIGHT, Velux TMR 014 0000, Sun Tunnel, pitched flashing, rigid tunnel, new, still-in-box, $150. Romero, 235-6738.

DAY BED, mahogany, excellent condition, $100. Jacobson, 898-1397.

ELLIPTICAL MACHINE, gym quality, Vision Fitness, $450; coffin-top treadle sewing machine, w/glass presser foot, $150. McKinney, 281-5685, ask for Judy.

BED, full size, box springs, firm mattress, 2-mo.-old frame, all in good condition, $75. Simon, 944-5282.

COUCH, oatmeal-colored, good condition, photos available, must sell, $150. Delgado, 505-554-9486.

KEYBOARD, Yamaha DGX620, portable piano, w/stand & bench, 88-key, weighted & graded, excellent condition, $425. Hietala, 505-610-1252.

WALL MIRROR, large, Southwest motif, blonde hardwood frame, 41" x 41", excellent condition, $49. Baney, 505-294-8970.

LEATHER COUCH, bluish white color, 78"L x 32"W x 30"H, excellent condition, $500. Lucero, 505-856-6293.

HEADPHONES, Beats Solo2, black, $160; XBox 360, 4GB bundle (Gold Live, 64MB memory, games) $250; unopened. Malone, 505-573-9061.

MICROWAVE, counter-top, Magic Chef, 0.7-cu. ft., black, like new, bought Jan. 2015, $40. Bigney, 235-9243.

BERNINA SERGER 800DL, barely used, maintenance service March 2015, like new. Hughes, 220-8977.

WASHER, used, white, great working order, you pick up, $75 OBO. Donnelly, 505-250-5146.

KNEE WALKER, 3-wheel, all terrain, gently used, 90% indoors, $300 or make reasonable offer. Gallegos, 505-331-9998.

TRUNDLE BED, oak, twin, w/nightstand, good condition, text for photos, $250. Hill, 803-8320.

MINI REFRIGERATOR, stainless steel/black, 20-1/2" x 31-1/2" x 21", $20; full/queen-size bed frame, $10. Burton, 505-550-5534.

FENDER P BASS, 1977, black, S746592, minor finish cracks, original case, $1,300; 4, vinyl windows, used, 4'x 6', Craigslist. Rector, 252-8799.

REAR PROJECTION TV, 40-in., works well, great for VHS tapes, free. Stubblefield, 263-3468.

JOGGING STROLLER, BOB Revolution, w/handlebar console, $250; Maclaren stroller, turtle sandbox, toddler swing, more. Greathouse, 821-0980.

TRANSPORTATION

'10 SUBARU LEGACY 2.5GT, 108K miles, kept in great condition, great family/sporty car, $13,500. Waymire, 505-615-6030, ask for Russel.

How to submit classified ads

DEADLINE: Friday noon before week of publication unless changed by holiday. Submit by one of these methods:

- **EMAIL: Michelle Fleming (classads@sandia.gov)**
- **FAX: 844-0645**
- **MAIL: MS 1468 (Dept. 3651)**
- **INTERNAL WEB: On internal web homepage, click on News Center, then on *Lab News* link, and then on the very top of *Lab News* homepage "Submit a Classified Ad." If you have questions, call Michelle at 844-4902. Because of space constraints, ads will be printed on a first-come basis.**

Ad rules

1. Limit 18 words, including last name and home phone (If you include a web or e-mail address, it will count as two or three words, depending on length of the address.)
2. Include organization and full name with the ad submission.
3. Submit ad in writing. No phone-ins.
4. Type or print ad legibly; use accepted abbreviations.
5. One ad per issue.
6. We will not run the same ad more than twice.
7. No "for rent" ads except for employees on temporary assignment.
8. No commercial ads.
9. For active Sandia members of the workforce, retired Sandians, and DOE employees.
10. Housing listed for sale is available without regard to race, creed, color, or national origin.
11. Work Wanted ads limited to student-aged children of employees.
12. We reserve the right not to publish any ad that may be considered offensive or in bad taste.

'02 TOYOTA MR2 SPYDER, white/black leather, new battery, brakes, tires, alternator, belt, oil change, 111K miles, $6,500. Burfeindt, 505-897-0179.

'99 FORD F350, Super Duty, 4x4, regular cab, AT, 157,884 miles, runs great, $4,500. Wyman, 414-9142.

'06 MAZDA MIATA MX-5, Grand Touring, 6-spd., standard, excellent mechanical, 20-ft. exterior, fun car, $7,500. Blejwas, 286-9294.

RECREATION

'05 KYMCO PEOPLE 250 SCOOTER, w/trunk & trickle charger, 12K miles, well cared for, $1,350 OBO. Verley, 410-9885.

'05 YAMAHA VSTAR, 650 cc, red/silver, saddlebags, low mileage, great condition, photos available, $3,000 OBO. Allen, 362-4082

MOUNTAIN BIKE, Ibis Mojo-SL, carbon/titanium, large >6-ft. frame, excellent condition, many spares, ready-to-ride, 1 owner, $1,499. Ritchey, 505-238-8123.

'12 R-VISION TRAILLITE CROSSOVER 200S TRAVEL TRAILER, nearly new condition, $14,850. Anaya, 505-235-4003.

REAL ESTATE

3-BDR. HOME, 1-1/2 baths, new roof, new stucco, tile accents, large laundry room, carport, storage shed, ~3.4-acre, in Taos, FSBO, $142,200. Gallegos, 505-898-9614.

3-BDR. HOME, 2 baths, 2,600-sq. ft., garage, cul-de-sac, scenic deck, guest suite (1-bdr., 1 bath), Cedar Crest, $298,000. Barnett, 505-573-9779.

2-BDR. CABIN, Ruidoso, 2-1/2 acres, horse stalls, near national forest, perfect for weekends or retirement, $169,000. Wolf, 856-8539.

2 ACRES, land only or build-to-suit, gorgeous mountain views, all utilities & new road, Sandia Park, $10,000 down, $105,000. Mihalik, 281-1306.

5-BDR. HOME, 3 baths, ~2,400-sq. ft., large beautiful lot, workshop, Eubank/Menaul area, MLS#841721, $235,000. Gibson, 294-6831.

2-BDR. HOME, 1-3/4 baths, 2-car garage, fireplace, remodeled interior, gated community, close to base & I-40, $142,500. Tobyas, 505-288-2221 or 505-274-1932.

FOR RENT, going on assignment for Sandia, 4-bdr. home, 2-1/2 baths, 2,965-sq. ft., landscaped, <2 miles to Labs, available mid-Aug., $1,600/mo. Chavez, 505-385-2574.

4-BDR. HOME, >3,100-sq. ft., 3-car garage, loft, on .35 acre lot, $379,000. Fitzpatrick, 505-269-0069.

WANTED

USED PAPERBACK NOVELS, westerns, mysteries, suspense, no chick lit, free or extremely cheap for bored elderly father. Bristol, 400-3421.

MOVING BOXES. Cuellar, 688-0370.

'BOOK OF MORMON' TICKETS, any performance. Luna, 872-0193 or 270-8611.

DOUBLE BIKE TRAILER, w/stroller conversion for off-road conditions. Goodner, 505-379-4023, call or text.

Good to go

(Continued from page 12)

The harsh realm of re-entry

Ballistic weapons are shot high into the atmosphere and come down fast. "Very high, very fast," Jeff says. "It's a severe environment." The vehicle carrying the weapon heats up from frictional loading as it re-enters the atmosphere. Aerodynamic or compressible fluid loads on the outside produce large rigid body accelerations and produce relative small random vibration. The random vibration loading is produced through a coupled fluid/thermal/structural process. "It's complex, coupled phenomena where fluid dynamic and thermal loadings drive the structural response," Jeff says.

The flight vehicles must be designed to complex specifications to ensure performance. Because the precise re-entry environment cannot be fully reproduced in ground testing or controlled in flight, researchers use computational modeling to get the loading and thermal condition of the vehicle correct and propagate those loads through the structure down to the component or subcomponents of interest.

Captive carry: point A to point B

Vibration also can wreak havoc when a weapon is carried in a bay of an airplane. As the aircraft prepares for weapon release, the bomb bay doors open, letting the external flow field enter the bay. Turbulent air flows over the top of the weapon cavity and produces broadband acoustical noise that produces random loads. "Resonant tones form in the cavity, putting additional unsteady load onto the test unit," Jeff says. "Getting that environment right with both the broadband acoustical noise and standing waves is difficult with a full-scale unit, so we rely more heavily on flight testing and modeling and simulation."

To ensure the accuracy of the models that predict the loading, subscale experimental data can be used to validate the modeling and give researchers a better understanding of the physics inside the cavity. "Flight testing and modeling move ahead in parallel and work together to push forward our predictive capabilities," Jeff says.

Anatomy of a test

The experimental process moves from basic to complex starting with simple models of the aircraft. A rectangular cavity is tested in a wind tunnel to understand the unsteady surface loading and low field features. These data are compared to the modeling and simulation predictions until researchers are confident they can anticipate its behavior. Complexity is added to the cavity geometry so it more closely represents a real bomb bay, with ramps and finer details within.

Engineers then experiment with a surrogate weapon in the cavity and develop a fluid and structural dynamics model. "This building block approach ensures both the loading and structural response is accurately predicted," Jeff says. "The final step is to compare the modeling and simulation predictions to operational flight test data."

The work is important because modeling and simulation improve ground and flight testing through better-designed experiments. With both re-entry and captive carry it provides a glimpse into what the environment will look like before a flight test. Engineers can advance life extension programs for nuclear weapons such as the B61 by designing and replacing limited-life components more efficiently. "With modeling and simulation we can provide the environments those components will see earlier in the process and do a better job of designing to those environments," Todd says.

Ensure mission success

Jeff, Todd, and their colleagues develop specifications for engineers in other areas of the Labs that design and build components and systems. On Nov. 17, 2011, Sandia's Integrated Systems Program did the first test flight of the Advanced Hypersonic Weapon (AHW), which was launched from the Lab's Kauai Test Facility. A Sandia-designed booster system launched the AHW glide vehicle and deployed it on the desired flight trajectory. The test demonstrated the viability of the boost-glide approach to long-range atmospheric flight and data collection on a variety of advanced technology subsystems.

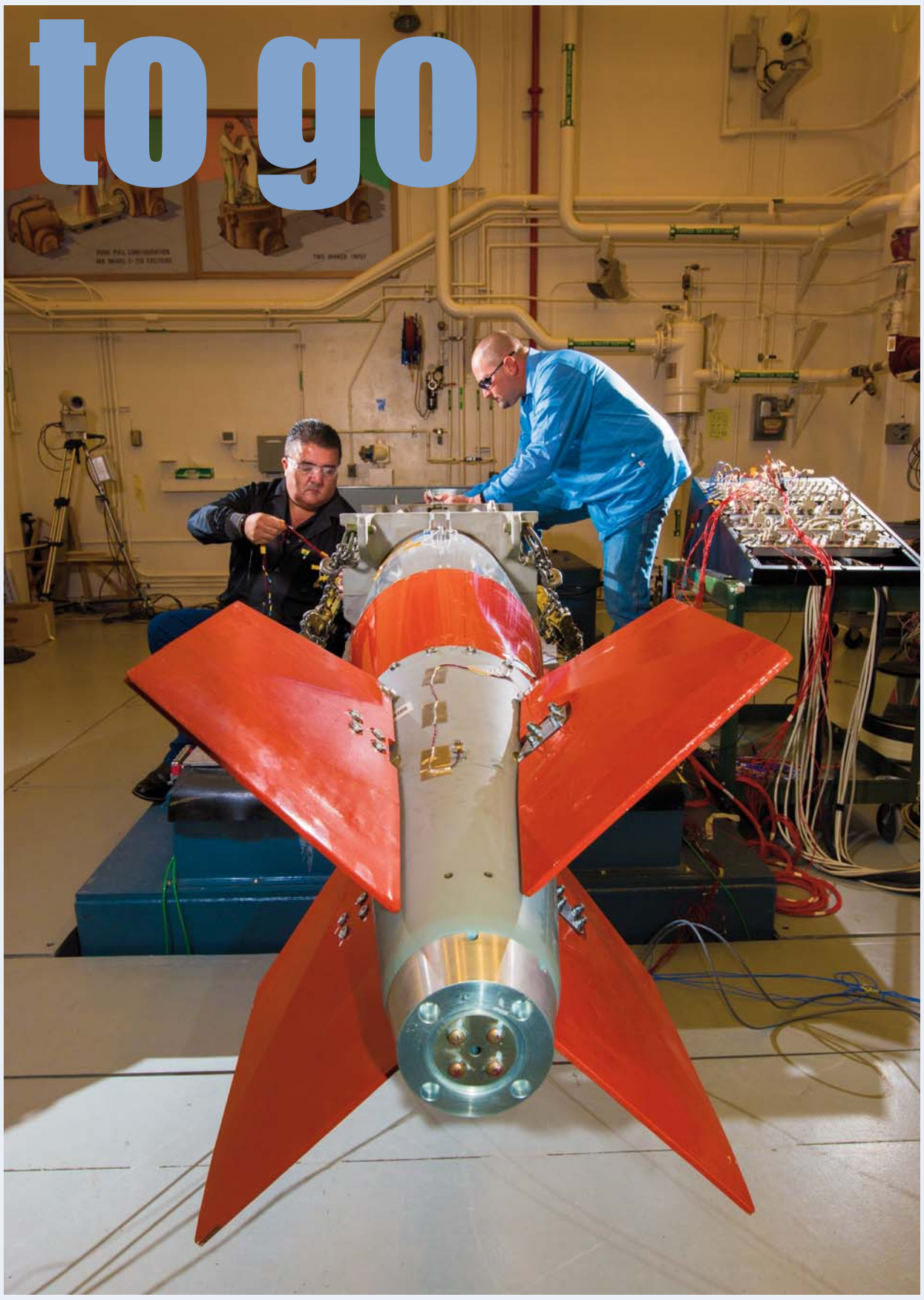
Todd says Sandia engineers built and analyzed the rocket superstructure around the third-stage motor, which launched the AHW, and results were used to develop control systems and assess flight worthiness.

"The purpose of our work is to ensure mission success by making sure the structures all can withstand the environments they will see during launch, release, and subsequent re-entry," he says. "The biggest thing we learn every time we do this program is the importance of having test data and analysis. They help each other. Trying to match the model to the test data, you learn a lot about your model, your test and the full system, the hardware and how it behaves."

Engineering Sciences touches programs across Sandia, from defense systems such as satellite payloads, hypersonic vehicles, and rail guns to energy systems including engine efficiency and wind turbine performance, and homeland security interests like aircraft safety and improvised explosives. The foundation's expertise includes solid mechanics, structural dynamics, combustion, thermal science, fluid mechanics, aerodynamics, energetics, electromagnetics and electrical sciences, and shock physics.

Other organizations recognize Sandia's computational expertise and have adopted the Lab's computer codes. "Engineering Science is constantly improving its tools and capabilities to provide deeper insight into the behavior of the systems and components that we design and are responsible for," Jeff says. "Through a combination of operational testing, computer simulation and experimentation, the Engineering Sciences Research Foundation is pushing the forefront of the technology used for designing and qualifying nuclear weapons. While Sandia's engineering sciences capability began and remains grounded in the nuclear weapons program, it has come to permeate every mission space of the laboratory."

Good to go



GO-TO GUYS — Technologists Curt Tenorio, left, and Jessie Fowler (both 1521) install instrumentation on a B61-12 unit for a vibration and shaker-shock test. It will be subjected to the amount of vibration and shock it would experience in a lifetime of transportation and aircraft captive carry environments.

By Nancy Salem • Photos by Randy Montoya

The world can be a rough and tumble place for the sensitive materials and electronics in weapons and other complex engineered systems. It takes skilled experimental testing with a big dose of computer modeling to be sure they will survive the ride.

A space vehicle hurtles toward Earth carrying a nuclear weapon and closing in on a barrier that will test it in countless ways. Standing guard is the atmosphere, gaseous layers 60 miles above the planet that keep objects from pummeling it to pieces.

Some are uncontrolled celestial or space debris, such as small meteoroids or pieces of old satellites. Others are controlled technology like a space vehicle, re-entering the atmosphere from a mission on a navigated course. Objects on a random trajectory break up or disintegrate when they hit the massive forces of atmospheric drag and aerodynamic heating.

The same fate awaits controlled spacecraft. But technological advances have made re-entry and extreme-velocity flight less damaging to payloads and electronics. Still, scientists need to know if the latest weapons, electronics, and other systems are tough and reliable enough to withstand re-entry and other kinds of transport.

MECHANICAL ENGINEER Sean Kearney (1512) studies jet flames with laser diagnostics to make temperature and soot measurements of the heat release from a fire onto a weapon system. "We want to understand how much heat gets transferred from the fire to the weapon," he says.

Sandia's Engineering Sciences Research Foundation is advancing the use of experimental ground and flight testing along with computational modeling and simulation to better predict system performance. "We're worried about the electronics and non-nuclear components of a weapon surviving the harsh vibration environments as the vehicle comes back into the atmosphere," says Todd Simmermacher, a manager in analytical structural dynamics. "It's very similar to what you see in the movie Apollo 13 when the astronauts are coming back and get jostled around, but 10 times more harsh. The concern is it will shake apart the electronics."

Aerosciences manager Jeff Payne says engineers simulate re-entry and other transport environments to evaluate components and determine if they will survive. The work covers a range of vibration environments including transportation, launch, and re-entry. Historically the bulk vibration data were gathered by flight and ground testing. "We measure how a weapon system responds to the flight environments and replicate that response on a shaker to collect data under tightly controlled conditions," Jeff says. "The flight data measure the performance of the vehicle in a particular re-entry setting but there is uncertainty in our knowledge of the exact atmosphere, speed, and temperature, and there are challenges relaying that data to the ground during flight."

Building a complete picture

The challenges produce uncertainties in the flight data that cannot be eliminated. The re-entry conditions the ground tests replicate can be tightly controlled but cannot fully reproduce the flight environment. "Modeling and simulation can be used to reproduce flight environments but care must be taken to ensure the physics models are accurate," Jeff says.

Modeling fills the gaps by simulating a larger variety of the flight conditions the vehicle could experience than can be explored through tests. "Typically on a flight test there are a limited number of trajectories that are flown," Todd says. "We want to expand that and cover its full operating envelope." Modeling and simulation also improve and complement testing by designing better tests and providing a detailed understanding of observed phenomena during testing.

The essential trio of flight testing, ground testing, and modeling and simulation together build the most complete picture of a system and how it performs.

"We use the strengths of each to solve complex problems," Jeff says. "The more complex the system, the more integrated the approach has to be. No one tool will provide you with everything you need. If a ground test can't get the environment right, we go to modeling. Sometimes the ground test is a high representation of the flight test and we don't have to rely on the modeling."

The Engineering Sciences Research Foundation has its roots in the nation's nuclear weapons program. The level of computational and experimental expertise was a natural outgrowth of the need for greater amounts and precision of data after underground nuclear testing ended in 1992. DOE investments in high-performance computers helped boost Sandia's computational expertise.

Researchers in engineering sciences are deeply involved in programs to modernize the nuclear stockpile. Their work is critical to Sandia's national security and nuclear weapons missions. "Being able to simulate these environments and better understand performance of the system and also better explore the design space is extremely important and hasn't been done in the past," Todd says.

(Continued on page 11)